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PROTECTION ERRORS IN OPERATING SYSTEMS:

A Selected Annotated Bibliography and Index to Terminology
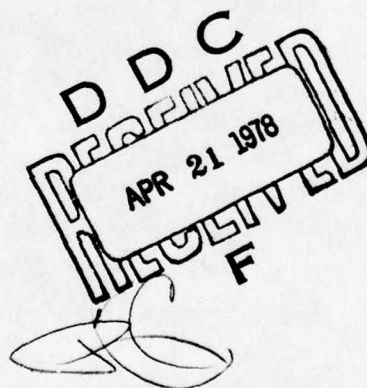
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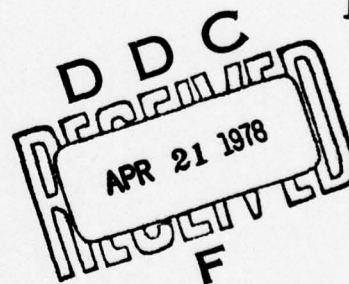ARPA ORDER NO. 2223

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20. ABSTRACT

This report represents the current state of a bibliography on the subject of protection in computer operating systems. "Current state" means that the bibliography is incomplete; it is a byproduct of a research project in the field of protection, recently completed. The bibliography is being published in the belief that it may be useful as is, and that it might serve as the basis of a continuing effort to collect, annotate and index the more significant documents (reports, papers, articles, books, etc.) in the field. Ideally (especially in these days of computerized information bases and communication networks) workers in a research field will collaborate in developing and sharing their bibliographies--not only with simple annotations like this one but with more extensive comments and reviews. Perhaps this document can be a contribution in that direction and will stimulate owners of other "working" bibliographies to publish theirs. As noted below, this bibliography is online and may be accessed via the ARPANET.

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INTRODUCTION

This report represents the current state of a bibliography on the subject of protection in computer operating systems. "Current state" means that the bibliography is incomplete; it is a byproduct of a research project in the field of protection, recently completed. The bibliography is being published in the belief that it may be useful as is, and that it might serve as the basis of a continuing effort to collect, annotate and index the more significant documents (reports, papers, articles, books, etc.) in the field. Ideally (especially in these days of computerized information bases and communication networks) workers in a research field will collaborate in developing and sharing their bibliographies--not only with simple annotations like this one but with more extensive comments and reviews. Perhaps this document can be a contribution in that direction and will stimulate owners of other "working" bibliographies to publish theirs. As noted below, this bibliography is online and may be accessed via the ARPANET.

Because this bibliography was incidental to other work rather than an end in itself, litle time was spent in trying to make it comprehensive, or in supplying extensive annotations. It will also be noted that relatively little material has been added during the past year.

With respect to its subject, this bibliography was always intended to cover only a limited set of topics within the larger fields of operating system and computer security, specifically the following:

Operating system requirements, policies and mechanisms, for insuring user and operating system program and data integrity and confidentiality.

The best way to get a feel for the topics included is to scan the index (see below). The following peripheral topics have been specifically excluded (except where they occur together with the main subject above):

User identification and authentication

Encryption

Hardware reliability

Error detection methods

System generation and initialization

Human integrity (e.g., administration and operations staff)

Physical installation security

Communications security

Broader economic, social, and political issues

A reviewed document was also not included if the bulk of its subject matter, as a whole and by section, was other than that described above, even though it may have contained relevant fragments.

Gray areas exist in which the boundaries of the protection field are not well defined. Ultimately, probably no completely satisfactory definition of protection exists that stops short of including the entire constraintive aspect of programming and operating systems, i.e., of including policies and mechanisms for all kinds of unintended occurrences.

Selectivity has also been based on quality and significance. The attempt was made to exclude documents deemed not to be potentially useful for future reference personally, and which could not be recommended to students of protection. Exclusion of such entries from published bibliographies should be a professional ethic, even at the expense of exposing the often subjective judgments of their editors.

In general, a reviewed document has been included in this bibliography if it was judged to contribute original and potentially helpful observations, insights, ideas, or descriptions; or to express old ones in new and potentially helpful ways.

A document was rejected for any of the following "editorial" reasons:

It has been superseded by a revision, or its essence has been republished in a more accessible source.

It is totally obsolete or is of historical interest only.

Its editorial quality is inadequate.

As a result of the level of effort put into it and the restrictions applied, only 173 entries appear. Approximately 154 documents that qualified by topic (at least to some extent) were reviewed and rejected or included and later dropped. In addition, about 65 entries are currently on my list of unseen documents whose titles suggest relevance.

A unique feature of this bibliography is its index. An indication of the maturity of a field of research is the extent to which its technical terms are defined and used consistently. Access to definitions and usages is especially important to students in the field. Also, the technical terms used usually comprise a fair index to the content of a document. For these reasons, and to experiment with the actual usefulness of such an index, as each document was reviewed its key terms, concepts, and topics were noted as a set of keywords. Little attempt has been made to standardize the forms occurring in the index, or to insure consistency, for example by going back to revise the

keyword set of a document reviewed two or three years earlier. None of the massaging ordinarily needed to enhance the usefulness of an index has been applied to this one; like the bibliography itself, it is published in its current unfinished state.

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Fields of an entry are separated by double spaces, except that the local identifier and the author-name field are separated by a tab character. Entries themselves are separated by null lines.

The following abbreviations occur in the bibliography:

ACMnn Proceedings, ACM Conference 19nn

CACM Communications of the ACM

IBM74d Data Security and Data Processing, Vol. 4 Study Results: Massachusetts Institute of Technology IBM G320-1374 74.6

ICRS75 Proceedings, International Conference on Reliable Software, April 21-23, 1975

IWCA73 Proceedings, International Workshop on Computer Architecture, Grenoble, June 26-28, 1973

IWPOS74 Proceedings, International Workshop on Protection in Operating Systems, Rocquencourt, France, August 13-14, 1974. Institut de

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Recherche d'Informatique et d'Automatique, BP 5 - Rocquencourt 78150
Le Chesnay, France

FJCCnn AFIPS Conf. Proceedings 19nn Fall Joint Computer Conference

NCCnn AFIPS Conf. Proceedings 19nn National Computer Conference

NTIS National Technical Information Service

PLOS73 Proc. of ACM SIGPLAN-SIGOPS Interface Meeting: Programming
Languages - Operating Systems, April 9-12, 1973

SJCCnn AFIPS Conf. Proceedings 19nn Spring Joint Computer Conference

SOSP75 Proc. of the Fifth Symposium on Operating Systems Principles,
November 19-21, 1975

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Tokubo, S.; Webb, D.A. & Linden, T.A. (ed.) Security analysis and
enhancements of computer operating systems. National Bureau of Standards
Institute for Computer Sciences and Technology NBSIR 76-1041 76.4 68p
[* Brief informal discussions of security flaws and enhancements; brief
design overviews and descriptions of flaws found in IBM's OS/MVT, the
UNIVAC 1100 series operating system, and the TENEX operating system
for the DEC PDP-10. *] <security enhancements, types; errors, integrity,
taxonomy/categories/examples>

AmbH77 Ambler, Allen L. & Hoch, Charles G. A study of protection in
programming languages. SIGPLAN Notices 12,3(77.3) (Proc. ACM Conf. on
Language Design for Reliable Software) 25-40 [* Compares protection
features of Pascal, Concurrent Pascal, Euclid, CLU, and Gypsy, with
respect to ,
using the "prison mail system" problem as an example. *] <access control
features, language; classes; protection principles, languages; selective
access>

Ames74 Ames, Stanley Richard, Jr. File attributes and their relationship
to computer security. Case Western Reserve Univ. Dept. of Computing and
Information Sciences Report No. 1167 74.6 89p [* Successively refined
models of a tree-structured file system to include security requirements
governing observation and modification of file attributes. *] <security
events/axioms; repositories; agents; security classes; observe relation;
modify relation; clearance; executors; clusters; view relation; alter
relation; manipulators; accumulations; looks-at relation; changes relation;
mandatory/discretionary controls>

Ande72a Anderson, James P. Information security in a multi-user computer
environment. Advances in Computers Vol. 12 Academic Press 1972 1-36
[* Includes a broad survey of problems, models, and mechanisms. *]
<isolation mechanisms; two state operations; i/o channels; virtual
machines; program identity; implied sharing; descriptors; classification,
derived>

Ande72b Anderson, James P. Computer security technology planning study.
ESD-TR-73-51, vol. II. 72.10 137p. [* Detailed research and development
proposal, to include security models, design of a <security kernel>, and
architecture, hardware, and systems studies. *] <reference monitor;
descriptor-based architecture; vulnerabilities, classes; implied sharing
vulnerability; scavenging problem; incomplete parameter checking;
asynchronous interrupt vulnerability; asynchronous i/o vulnerability;
trojan horse problem; file authorization; authorization, files;
hierarchical access control; data management systems; aggregation;
inference; procedural controls>

Andr74 Andrews, G.R. COPS--a mechanism for computer protection.
IWPOS74 5-25 Also, Cornell Univ. Dept. of Computer Science CU-CSD-74-
214 74.10 35p [* <Capability-based protection mechanism>. *] <actor,
process/procedure; mechanism, def.; principle of control; manager problem;
mutual suspicion; confined computation, def.; protection state; monitors;
primitives, protection state/environment; information structures, control/
computing; capabilities; attributes, access/control; environment; basic
monitor; message confinement; protection, logical vs. physical>

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102-116

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SIGARCH-SIGOPS Workshop on Virtual Computer Systems, 73.3 ACM 1973
206-209 [* <Virtual machines, security advantages>. *] <intention,
explicit>

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machine systems. IBM Research RC 5617 (#22625) 74.11.14 12p
[* Proposed method of allowing communication between virtual machines by
extending each with a virtual control store (VCS) and virtual
microprocessor, protected from the user. *]

Bar+67 Barron, D.W.; Fraser, A.G.; Hartley, D.F.; Landy, B. & Needham,
R.M. File handling at Cambridge University. SJCC67 163-167 [* Early
<file access control scheme>. *] <part owner>

Baum75 Baum, I.R. The architectural design of a secure data base
management system. (Thesis) Ohio State Univ. Computer and Information
Science Research Center 1975

BelL73a Bell, D.E. & LaPadula, L.J. Secure computer systems: mathematical
foundations. Mitre Corp. MTR-2547, vol. I ESD-TR-73-278, vol. I 73.11
37p NTIS: AD-770 768 [* Formal model defined from the viewpoint of
general systems theory. *] <security, def.; classifications; need-to-know
categories; access attributes; request sequences; decision sequences;
access matrices; state sequences>

BelL73b Bell, D.E. & LaPadula, L.J. Secure computer systems: a
mathematical model. Mitre Corp. MTR-2547, vol II ESD-TR-73-278, vol. II
73.11 58p NTIS: AD-771 543 [* Enhancement of the model presented in
[BelL73a]; <privacy restrictions> are shown to be enforced under certain
state transformations. *] <access attributes; access matrix; control
access; error decision; question decision; security condition; *-property;
security principle; interactivity principle; tranquility principle;
classifications; categories (access privileges); request sequences;
decision sequences; state sequences; rule, def.; rules of operation>

Bell74 Bell, D.E. Secure computer systems: a refinement of the
mathematical model. Mitre Corp. ESD-TR-73-278, Vol. III MTR-2547, Vol.
III 74.5

BelL76 Bell, D.E. & LaPadula, L.J. Secure computer system: unified exposition and Multics interpretation. Mitre Corp. MTR-2997 ESD-TR-75-306 76.3 129p

BelW74 Belady, L.A. & Weissman, C. Experiments with secure resource sharing for virtual machines. IWPOS74 27-33 [※ Results and methodology of VM/360 evaluation. ※] <isolation; sharing, information vs. other resources; channel programs, vulnerabilities; asynchronous modification of instructions; security, def.>

Bing65 Bingham, Harvey W. Security techniques for EDP of multilevel classified information. Burroughs Corp. 4424-65-112 65.12 186p NTIS: AD-476 557 [※ Includes broad treatment of early hardware and software mechanisms. ※] <user control profile; program reference table; file control code>

Bis+75 Bisbey, Richard, II; Popek, Gerald & Carlstedt, Jim Protection errors in operating systems: inconsistency of a single data value over time. Univ. of Southern California Information Sciences Institute ISI/SR-75-4 75.12 16p [※ Type of protection error in which the value of a variable can be changed between two operations for which it is assumed to remain constant. ※] <consistency, single variables; time-of-check-to-time-of-use error; parameter passing; errors, examples>

Bran73 Branstad, Dennis K. Privacy and protection in operating systems. Computer 6,1(73.1) 43-46 Also, Operating System Review 7,1(73.1) 9-17 [※ Report of Workshop on Privacy and Protection in Operating Systems, Princeton, NJ, June 12-14, 1972. ※] <generic weaknesses; residue; parameter checking, incomplete; asynchronous i/o; trojan horse attack; covert channels>

Brat75 Bratt, Richard Glenn Minimizing the naming facilities requiring protection in a computing utility. MIT Project MAC TR-156 Also, Honeywell Information Systems Federal Systems Operations ESD-TR-76-161 75.9 129p [※ Simplification of the Multics security kernel by removing <reference name space> management and directory pathname resolution. ※]

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Brow71 Browne, Peter S. Data privacy and integrity: an overview. 1971 ACM SIGFIDET Workshop: Data Description, Access and Control 237-240 [※ Basic distinctions. ※] <privacy; integrity, data; input validation;

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isolation; identification; authorization>

Burk74 Burke, Edmund L. Synthesis of a software security system. ACM74
648-658 [* Software verification schema based on four <levels of
representation>--mathematical model, <formal specification>, algorithms,
and machine language; sketch of its application to the MITRE security
model and a <security kernel> for the PDP 11/45. *] <reference monitor>

Car+71 Carroll, John M.; Martin, Robert; McHardy, Lorine & Moravec, Hans
Multi-dimensional security program for a generalized information retrieval
system. FJCC71 571-577 [* Scheme for controlling access at the file,
record and item levels. *] <item key; item code; record key; record code;
data base scheme; record level control; field level control>

Carl76 Carlstedt, Jim Protection errors in operating systems: validation
of critical conditions. Univ. of Southern California Information Sciences
Institute ISI/SR-76-5 76.5 33p [* Type of protection error in which
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holds. *] <validation errors; errors, examples; validity vs. integrity;
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and locking in a relational data base system. NCC75 425-430 [* "Views
prescribe what can be seen. Authorization prescribes what can be done to
what is seen. Locks are a dynamic kind of authorization which prescribe
what can be done to what is seen at this instant." *] <views, data base;
authorization types, data base; grant; revocation; access control, data
base; value dependent authorization>

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integrity. (Letter) IBM Systems Journal 15,3(76) 264-269 [* Criticism
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<hierarchically structured systems; security, def.; privacy, def.;
integrity, def.; mechanism requirements; isolation, def.; security kernel>

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1975 260p

CohJ75 Cohen, Ellis & Jefferson, David Protection in the Hydra
Operating System. Operating Systems Review 9,5(1975) (SOSP75) 141-160
[* Description of the Hydra protection mechanisms and their application
to several well-known <protection problems>. *] <protection, access/
control; decisions, prior/future; decisions, unilateral/negotiated;
procedural embedding; capabilities; ownership; subsystems; amplification;
rights, generic/auxiliary; C-list; templates; domains; seal/unseal; rights,
required/new; mutual suspicion; modification; propagation; conservation;
confinement; initialization; revocation, immediate/permanent/selective/
partial/temporal/sharing; freezing; accounting; lost objects; aliases>

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of security measures in information systems. CACM 15,4(72.4) 211-220

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be made more efficiently at compile time. *] <access matrix; virtual
user; data dependent conditions; compile time access control; security vs.
privacy; decision rule; column system; diagonal system; compile-time
checking>

Con+72b Conway, R.W.; Maxwell, W.L. & Morgan, H.L. Selective security
capabilities in ASAP--a file management system. SJCC72 1181-1185
[* <Data base scheme> incorporating both <record level control> via
<access control lists> and <field level control> via a <lock-and-key
mechanism>. *] <directory of authorized users; security class, field;
compile-time checking>

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real-time applications. Proc. First Intern. Conf. on Computer
Communication. IEEE Computer Society or ACM 282-289 [* Includes a brief
description of the <capability architecture> of the Plessey System 250. *]
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mechanism. IWPOS74 35-53 [* Capabilities are treated as protected data
structure pointers that can be freely copied. *] <capability segments;
segment as unit of protection; control, transfers of; capabilities vs.
pointers>

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IBM's Resource Security System, among other things by allowing
disseminated control of authorization and providing for <protected
subsystems>, including <execute-only access> to programs. *] <security
officer; user groups; file groups; authorization classes; access types>

DalN65 Daley, R.C. & Neumann, P.G. A general-purpose file system for
secondary storage. FJCC65 213-229 [* Early description of the Multics
file system. *] <hierarchical access control; file directories; access
paths; usage attributes; access control lists; trap list>

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subsystems. IWPOS74 55-61 [* Implementation of a <confinement
mechanism> satisfying several necessary properties, and its
insufficiency. *] <confinement problem; error conditions; protected
subsystems; selective confinement; engagement; mutual exclusion, customer
processes; closure, confidentiality; nonleakage; transitivity of
engagement; declassification; disengagement; nonretention; covert channels;
compile-time checking>

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it that verifies the security of information flow in a program, including
the <confinement property>. *] <security classes; flow relation/policies;
property lattice>

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Denn65 Dennis, Jack B. Segmentation and the design of multiprogrammed computer systems. J. of the ACM 12,4(65.10) 589-602 [* "...Hence it is preferable that a protection mechanism operate in the name space of a computation..." *]

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Denn76b Denning, Peter J. Fault tolerant operating systems. ACM Computing Surveys 8,4(76.12) 359-389 [* Broad tutorial and survey: how <capability architectures> facilitate the techniques required for <confinement of errors>. *] <process isolation; environment, open/closed; capability list; access code; name, local/system; access list; storage capability; enter capability; multiple domain processes; protected entry; domain changing; attenuation of privilege; privilege state mechanism; privilege number; descriptors, privacy; virtual machines; resource control; decision verification; encapsulation, process>

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accesses, normal vs. security update; breaches, internal vs. external>

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protection in computer systems. Univ. of Colo. Department of Computer
Science. CU-CS-043-74 74.5 46p NTIS: PB-235 297 [* Defines
absolute, relative, and minimum <degree of protection> in terms of
assignments of <access codes> to subjects and objects, gives assignments
that maximize these, and applies this to hierarchical systems. *]
<isolation level>

Engl72 England, D.M. Architectural features of System 250. Infotech
State of the Art Report on Operating Systems. 1972 12p [* Description
of the <capability architecture> of the Plessey System 250. *]
<privileged mode, nonnecessity; capability registers; enter access>

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System 250. IWPOS74 63-82 [* "...everything...is reducible to data
structures...built up from...an interconnected network of
capabilities..." *] <capability architecture; capability registers,
real/virtual; load/store, capabilities; central capability segment; enter
capability; privileged mode, nonnecessity; resources as protected data
structures>

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control of access in an interactive computer. SJCC67 23-30 [* Proposal
for integrating access control into the (virtual) addressing and parameter-
binding mechanisms of an operating system. *]
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oriented around capabilities. Univ. of Chicago Institute of Computer
Research Quarterly Progress Report No. 18, I-B 1-97 68.8 [* Sketch of
design and implementation. *] <supervisor as interaction controller;
capabilities; capability registers; segment as unit of protection; virtual
machines; capability segments; access codes; capabilities, user; enter
access>

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decision involving process interactions. *] <isolation; message system>

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403-412 [* Rationale, comparison, and implementation considerations of
schemes in which addresses are capabilities containing unique segment
identifiers. *] <capability-based addressing; capabilities,
representation integrity, approaches; capabilities and storage allocation;
enter access/instruction>

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structure for protected systems' design. IWPOS74 83-105 [* Object and
type construction/destruction and call/return operations in a <capability-
based system, extensible>. *] <agents; objects; mutual suspicion;
transition type; descriptor (capability); encapsulated type; case/uncase
operators; domains; environment of domain; operators, strong/weak; kernel;
type transformation; call/return operations, domain>

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[* Access matrix is extended to allow entries to contain predicates that
depend on any data in the data base; most checking is done at compile
time. *] <data base access control; access matrix, extended; access
predicates; allocate (access type); functional access; administer (access
type); inherit (access type); use (access type); compile-time checking>

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Systems J. 9,4(1970) 258-280 [* Broad treatment of access control
requirements and considerations, recommending <compartmentalization> and
data element <tagging>. *] <integrity, system; authorization, def.;
privilege structure, complexity; names, concealment; passwords, file;
privileges, program/user; field, protected; isolation, authorization
mechanism; single-tag rule; group (protection category); levels of
classification, undesirability; authority hierarchies, undesirability;
clique, user; matrix, user-privilege; user profile>

Gain72 Gaines, R. Stockton An operating system based on the concept of
a supervisory computer. CACM 15,3(72.03) 150-156 [* <File access
control> via a <lock-and-key scheme>. *] <protection categories, file/
process, read/write>

GeoS73 George, James E. & Sager, Gary R. Variables--bindings and
protection. SIGPLAN Notices 8,12(73.12) 18-29 [* Six "mini-languages"
differing in their schemes for controlling the scope and accessibility of
names. *] <names, scope/sharing/protection>

Gla+75 Gladney, H.M.; Worley, E.L. & Myers, J.J. An access control
mechanism for computing resources. IBM Systems J. 14,3(1975) 212-228

Grah68 Graham, Robert M. Protection in an information processing utility.
CACM 11,5(68.5) 365-369 [* Protection requirements, and a model
featuring <rings of protection>. *] <privileged instructions, deficiency;
need-to-know principle; two-mode systems, deficiency; layers of protection,
advantages; segment as unit of protection; access bracket; call bracket;

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ring bracket; user descriptor; gatekeeper; calls, cross-ring; asynchronous modification of arguments>

GraD72 Graham, G.Scott & Denning, Peter J. Protection--principles and practice. SJCC72 417-429 [☆ <Access matrix model>: enforcement rules, protection commands, applicability, and implementation considerations. ☆] <levels of protection; mutually suspicious subsystems; memoryless subsystems; completeness requirement; objects; subjects; access rules, requirements; protection state; access attributes; monitor, object type; identification, subjects; update rules, access matrix; copy flag; owner attribute; control attribute; transfer command; grant command; copy flag, transfer-only; domains; hierarchies, subject, advantages; universal subject; untrustworthy subsystems; indirect access; debugging problem; trust; trustworthy subjects; revocability; c-list; access control list; authority list; lock list; key>

Grah71 Graham, G.Scott Protection structures in operating systems. (Masters Thesis) Univ. of Toronto Department of Computer Science 71.8

GriW76 Griffiths, Patricia P. & Wade, Bradford W. An authorization mechanism for a relational data base system. IBM Research RJ 1721 (#25154) 76.2.11 32p [☆ Mechanism providing for restricted sharing of data bases by allowing the granting and revocation of privileges and the definition and sharing of <views>. ☆] <data base privacy mechanisms; revocation, recursive; grants, labeled>

Har+75 Harrison, Michael A.; Ruzzo, Walter L. & Ullman, Jeffrey D. Protection in operating systems. CACM 19,8(76.8) 461-471 [☆ <Safety> of a protection system modelled by a given general <access matrix model> is undecidable. ☆] <rights, generic; configuration, protection system; own right; leaking, rights; undecidability, safety>

HarH75 Hartson, H.R. & Hsiao, D.K. Languages for specifying protection requirements in data base systems. Part I. Ohio State Univ. Computer and Information Sciences Research Center OSU-CISRC-TR-74-10 75.1 67p NTIS: AD/A-006 280 [☆ Models the <authorization process> and the <enforcement process> in a <security space> of users, authorizers, resources, operations, and value states. ☆] <access control model; authorization specification, validity/consistency; access condition; protection specification language; access matrix model, limitations; ownership, absolute/conditional; system administrator; withdrawal of rights; subownership; memoryless specifications; access history; authorized subspace; dominance, access history; access decision timing; domain of authorization; auxiliary invocation, domain; validation of inputs; progressive authorization; amplification; extended resources; franchise, user/operation/resource unit; partial rejection>

Harr75 Harrison, Michael A. On models of protection in operating systems. Lecture Notes in Computer Science. Vol 32: Mathematical Foundations of Computer Science 1975 (J. Becvar, ed.) Springer-Verlag 1975 46-60

Hart75 Harston, R. Rex Languages for specifying protection requirements

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in data base systems--a semantic model. Ohio State Univ. Computer and
Information Science Research Center CISRC-TR-75-6 75.8 248p NTIS:
AD-018 284/0GA

Hel+75 Held, G.D.; Stonebraker, M.R. & Wong, E. INGRES--a relational
data base system. NCC75 409-416 [* Access is controlled and integrity
assured by means of <query modification>. *] <access control, data base;
integrity, data base; restrict statement; integrity constraint>

HinS75 Hinke, T.H. & Schaefer, Marvin Secure data management system.
System Development Corp. TM-(L)-5407/007/00 RADC-TR-75-266 75.11 197p
NTIS: AD-A019 201

Hoff71 Hoffman, Lance J. The formulary model for flexible privacy and
access controls. FJCC71 587-601 [* Proposes a <formulary> procedure to
intercept all accesses to the data element to which it is attached and
to determine the right of access, possibly via a dialogue with the user. *]
<control profile, user; authority item; data dependent decisions>

HolB76 Hollingworth, Dennis & Bisbey, Richard, II Protection errors in
operating systems: <allocation/deallocation residuals>. Univ. of
Southern California Information Sciences Institute ISI/SR-76-7 76.6
17p [* Type of protection error in which a residual from a previous
allocation remains accessible after a new allocation. *] <residual,
content/access; errors, examples>

Hsi+74 Hsiao, D.K.; Kerr, D.S. & McCauley, E.J., III A model for data
secure systems (Part I). Ohio State Univ. Computer and Information
Science Research Center OSU-CISRC-TR-73-8 74.2 44p [* General
protection specifications can be used to define users' views (and
accessibility domains) of a data base, since they have the same form as
retrieval specifications (Boolean functions). *]

Hsia68 Hsiao, David K. A file system for a problem solving facility.
(Thesis) University of Pennsylvania The Moore School of Electrical
Engineering Report No. 68-33 68.5 157p NTIS: AD-671 826 [* Both <file
access control> and <record level control>, based on information in the
<authority item> associated with each user. *] <login program, file;
owner; authentication, file login program>

HsiM74 Hsiao, D.K. & McCauley, E.J., III A model for data secure systems.
(Part II) Ohio State Univ. Computer & Information Science Research
Center OSU-CISRC-TR-74-7 74.10 45p

IBMx71 (anon) OS/MVT with resource security: general information and
planning manual. IBM GH20-1058-0 71.12 28p [* Description of
Resource Security System features. *] <security levels; access category;
need to know; security officer; definition of controlled resources;
grouping of users and resources; authorization; program-restricted data
sets; associative programs>

Jans74 Janson, Philippe Arnaud Removing the dynamic linker from the

security kernel of a computing utility. (Thesis) MIT Project MAC TR-132
74.6 128p [* Protection implications and design of a <dynamic linker>
external to the security kernel, in terms of an abstract storage, name
space, and protection model; implementation in Multics. *] <principle of
least privilege; security kernel, criteria; object; subject; capability;
gate; protected subsystem; name space model; system initialization; link
fault handling; static storage allocation; rings, protection>

Jone73 Jones, Anita K. Protection in programmed systems. (Thesis)
Carnegie-Mellon Univ. Department of Computer Science 73.6 145p NTIS:
AD-765 535 [* Model of a protection mechanism based on <environments>:
collections of <constituent rights>, associated with objects or their
components; <declared rights>, associated with procedures; and <dynamic
rights>, associated with procedure invocations. *] <environment crossing
operators; protection, def.; object; access; type; enforcement rule; right
transfer rule/primitives; capability; ownership; access matrix;
environment binding rule; environment representations; checking, dynamic
vs. static; parameter passing; amplification; protection state,
transformations, closure; memoryless procedure; dynamic type creation;
subsystem; suitability factor; need-to-know principle; accuracy measure;
protection systems, comparison; policy vs. mechanism>

JonL75 Jones, Anita K. & Lipton, Richard J. The enforcement of security
policies for computation. Operating Systems Review 9,5(75) (SOSP75)
197-206 [* For any viewing program and any security policy there exists
a sound and <maximally complete mechanism>, but which cannot always be
constructed; construction of sound <surveillance mechanisms>. *] <v
functions; o operators; high water mark; policy, def.; mechanism, def.;
soundness; completeness; confinement; memoryless subsystems; data security;
observability postulate; information control vs. access control>

JonL76a Jones, Anita & Lipton, Richard J. (Letter) Operating Systems
Review 10,2(76.4) 7-8 [* Reply to [Rote76] on the <soundness> of the
privacy restriction mechanism at issue. *]

JonL76b Jones, Anita K. & Liskov, Barbara H. A language extension for
controlled access to shared data. IEEE Trans. on Software Engineering
SE-2,4(76.12) 277-285 [* Rules enforceable at compile time governing
the binding of <capabilities (variables)> to strongly typed, structured
objects, and implementing a wide class of controlled sharing policy. *]
<compile-time checking; type-module; qualified type; binding rules;
amplification>

JonW75 Jones, Anita K. & Wulf, William A. Towards the design of
secure systems. Software--Practice and Experience 5,4(75.10-12) 321-336
[* Distinction between policies and mechanisms; capability-based
mechanisms; the Hydra mechanism; types and examples of policies that
can be implemented in Hydra. *] <objects; security policy, def.;
appropriateness, policy; requirements, protection mechanisms; data base
protection; capabilities, extended; mechanisms, functions; amplification;
local name space; rights, kernel/auxiliary; capability transfer operations;
environment crossing operations; checkrights; amplifyrights; template;

courier policy; monitoring policy; revocation policy; confinement policy;
filtering policy; gatekeeper>

KamU77 Kam, John B. & Ullman, John D. A model of statistical databases
and their security. ACM Trans. on Database Systems 77.3

KarS74 Karger, Paul A. & Schell, Roger R. MULTICS security evaluation:
vulnerability analysis. USAF Electronic Systems Division ESD-TR-74-193,
Vol. II 74.6 155p [* Overview of Multics security controls; detailed
descriptions of several vulnerabilities identified, confirmed, and
exploited during an early 1973 analysis. *] <multi-level security;
master mode; access control lists; rings, protection; subverter program;
vulnerabilities, descriptions; validation of arguments, insufficient;
penetration techniques; trap doors, classes; procedural vulnerabilities;
utility programs, dump/patch; compiler trap doors; gatekeeper>

KohG75 Kohout, L. & Gaines, B.R. The logic of protection. Lecture Notes
in Computer Science, Vol. 34 GI--5. Jahrestagung Springer-Verlag 1975
736-751

Lack74 Lackey, R.D. Penetration of computer systems. An overview.
Honeywell Computer J. 8,2(74) 81-85 [* Categories of <penetration
techniques> and some common <error types>. *]

Lam+77 Lampson, B.; Needham, R.; Randall, R. & Schroeder, M. Protection,
security, reliability. Operating Systems Review 11,1(77.1) 12-14
[* Things to be done; misconceived problems. *] <absolute vs. defensive
protection; numerical measure of security>

Lamp67 Lampson, Butler Wright Scheduling and protection in an interactive
multi-processor system. (Thesis) Univ. of Calif., Berkeley 67.3 82p
[* <Control protection> via a per-process vector of allowable instructions;
<memory protection> implications of various addressing schemes. *]

Lamp68 Lampson, Butler W. A scheduling philosophy for multiprocessing
systems. CACM 11,5(68.5) 347-360. [* Includes the scheme for <control
protection> presented in [Lamp67]. *]

Lamp69 Lampson, B.W. Dynamic protection structures. FJCC69 27-38
[* Detailed treatment of <capabilities> and <domains>, especially with
respect to problems of <control transfers> and sharing. *] <access key;
rings; gates; proprietary programs; passwords, file; access control lists>

Lamp71 Lampson, Butler W. Protection. Operating Systems Review
 8,1(74.1)
18-24 [* Use and possible implementations of the <access matrix>. *]
<domain; message system; identification; object system; access attributes;
copy flag; revocation; ownership; capability list; access key; access lock
list; access control procedure, per object>

Lamp73 Lampson, Butler W. A note on the <confinement problem>. CACM
16,10(73.10) 613-615 [* The problem of preventing a <service program>

from leaking information. *] <covert channels; memorylessness; transitivity of confinement; masking, channels>

Lamp74 Lampson, Butler W. Redundancy and robustness in memory protection. Proc. IFIP Congress 74, Vol. 1 North-Holland/American Elsevier 1974 128-132 [* Approaches to protection as the control of efficient communication between memory-sharing domains, as opposed to protection as isolation of message-sending/receiving domains. *] <domain; chattels; protection, def.; protection, absolute/defensive; isolation; message model; memory environment; scope of domain; communication by value vs. pointer; authentication; trademarks; registrar; memory protection; sharing, slow/ fast; capabilities>

LamS75 Lampson, Butler W. & Sturgis, Howard E. Reflections on an operating system design. CACM 19,5(76.5) 251-265 [* Strengths and weaknesses of the capability-based Cal operating system in retrospect. *] <capabilities; domains; c-lists; seals; access keys>

Laue74 Lauer, H.C. Protection and hierarchical addressing structures. IWPOS74 137-148 [* Advantages/disadvantages and protection implications of <nested address space systems> versus <global object name systems>. *] <scope of names>

Less68 Lesser, V.R. A multi-level computer organization designed to separate data-accessing from computation. Stanford Univ. Computer Science Department Tech. Rep. CS90 68.3

Lind73 Lindsay, Bruce Suggestions for an extensible capability-based architecture. IWCA73 20p [* Possibilities for the representation, protection, passing, creation, interpretation, & encapsulation/retrieval of <capabilities>.*]

Lind74 Linden, T.A. Different goals for protection. IWPOS74 149-153 [* A protection mechanism should (1) provide for rigorous data security, (2) facilitate the construction of reliable software, (3) support the implementation of special protection mechanisms, and (4) aid in guaranteeing the protection mechanism's own integrity and correctness. *] <goals, protection mechanisms>

Lind76a Linden, Theodore A. Protection: a nuisance or an opportunity? Digest of Papers, COMPCON Fall 76 IEEE 30-35

Lind76b Linden, Theodore A. Operating system structures to support security and reliable software. ACM Computing Surveys 8,4(76.12) 409-445 [* Tutorial on small protection domains implemented via <capability-based addressing>; <extended-type objects>; and the applicability of these to reliable software and system security. *] <security, def.; subjects; objects; access modes; access right; domains; capabilities; access matrix model; domain switching; protected procedure; enter right; mutual suspicion; principle of least privilege; defensive programming; Trojan horse problem; intermediaries; directories; revocation; amplification; indirection; extended-type manager; modularity;

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discretionary/nondiscretionary controls; classification systems>

Lipn72 Lipner, Steven B. Computer security research and development
requirements. The MITRE Corporation MTR-142 73.2 <reference monitor;
need to know; segment, basis for access control>

Lipn75 Lipner, Steven B. A comment on the confinement problem.
Operating Systems Review 9,5(1975) (SOSP75) 192-196 [* Formalization
of confinement requirements in terms of the <*-property> and an approach
to proving that this property hold for all <storage channels> and
<legitimate channels> of an operating system; comment on the use of
<virtual time> to eliminate <covert channels>. *] <confinement problem;
hiding, information; high water mark; o-functions; v-functions>

LisZ74 Liskov, Barbara & Zilles, Stephen Programming with
data types>. SIGPLAN Notices 9,4(74.4) (Proc. Symp. Very High Level
Languages) 50-59 [* A form of <encapsulation> is provided by defining
classes of objects in terms of the <cluster of operations> available on
them. *] <type checking>

Mano71 Manola, Frank A. An extended data management facility for a
general-purpose time sharing system. (Master's thesis) Univ. of
Pennsylvania 71.05 NTDS: AD-724 801 160p [* Extensions to scheme
of [Hsia68]: <deny/allow descriptions> for <record level control>;
<field level control> by deleting restricted keywords and corresponding
fields from accessed records. *]

ManW75 Manola, Frank A. & Wilson, Stanley H. Data security implications
of an extended subschema concept. Naval Research Laboratory Report 7905
75.7.15 16p

Mart73 Martin, James Security, accuracy, and privacy in computer systems.
Prentice-Hall 1973 640p [* Includes descriptions of a variety of
authorization schemes, including IBM's Resource Security System. *]
<data security, def.; authorization structures; stratification;
compartmentalization (isolation); authorization tables, user/data;
transaction types; categories, user/data; locks, data record; passwords,
file; capability (training); lockwords; zones, data; authorization level;
security levels; access categories; need to know; integrity, system;
security officer; program restricted data; security by association>

Mcph74 McPhee, W.S. Operating system integrity in OS/VS2. IBM Systems
J. 13,3(74) 230-252 [* Seven types of <system integrity> errors in
forerunner systems, and their solutions in OS/VS2. *] <time-of-check-to-
time-of-use problem; validity checking; identification, objects; storage
protection; restricted names; authorized program facility; program
authorization; user-supplied addresses; serialization mechanisms; user
data passed as system data; errors, types/examples>

Mil175 Millen, Jonathan K. Security kernel validation in practice.
CACM 19,5(76.5) 244-250 [* Detailed description of method and techniques
used to prove security properties of a kernel for the PDP-11/45. *]

<security kernel; *-property; simple security condition; descretionary
access control matrix; tranquility principle; indirect information paths;
O-functions; V-functions; elimination rules; channels, legitimate/covert;
time problems>

Mins76a Minsky, Naftaly Intentional resolution of privacy protection in
database systems. CACM 19,3(76.3) 148-159 [* Operations on data
retrieved from a data base by a user program (assumed written in a
strongly typed language) can be restricted more strongly than with access
control alone, by requiring the program to interact via a subschema
containing <application rules> augmenting those of the given language. *]
<intentional resolution; privacy (security); access control limitations;
database protection; database subschema; right (part of application rule);
brands; data analysis, prevention; intermediate results, hiding;
confinement; confidence modules>

Mins76b Minsky, N. An activator based protection mechanism. Rutgers
Univ. Dept. of Computer Science Technical Report No. 25 76.6 40p

MooC74 Moore, Charles G., III & Conway, Richard Program predictability
and data security. Cornell Univ. Dept. of Computer Science TR 74-212
74.9 12p [* Capabilities can be controlled at the source language level,
allowing identification of potential <indirect access> via analysis of
the <information flow graph> as well as some <compile-time enforcement>,
provided that the name interpretation and accessing semantics of that
language are correctly defined and implemented.*] <security matrix>

Moor73 Moore, B.J. A classification of central processor architecture.
IWCA73 19p [* Basic architectural concepts and the relationships between
them, including processes, address spaces, and protection domains and
mechanisms. *]

Moor74 Moore, Charles G., III Potential capabilities in Algol-like
programs. Cornell Univ. Dept. of Computer Science TR 74-211 74.9 19p
[* Potential flow of information in either direction between a given
uninterpreted block B and a given variable may be determined from the
<information flow graph> (for which the construction algorithm is given)
of the program in which B is contained. *] <path condition; flow
condition; capabilities, potential>

Morr73a Morris, James H., Jr. Protection in programming languages.
CACM 16,1(73.01) 15-21 [* Proposes <seals> and <trademarks> for
maintaining privacy and integrity of program module data. *]

Morr73b Morris, James H., Jr. Types are not sets. Conf. Record of ACM
Symposium on Principles of Programming Languages, 73.10.1-3 120-124
[* Introduction of <seal operators, opaque/transparent> to guarantee the
integrity of operators on and representations of objects of dynamic
types. *] <authentication (type checking); secrecy (of representations)>

Need72 Needham, R.M. Protection systems and protection implementations.
FJCC72 571-578 [* Per process <capability segments>; addressing via

<indirection tables> in which segment names are bound. *]

Need73 Needham, R.M. Protection--a current research area in operating systems. International Computing Symposium 1973. North-Holland/American Elsevier Publishing Company 1974 123-126 [* Motivation for and description of the capability/domain approach. *] <mechanisms, def.; security of information, def.; Trojan horse problem; file access via given program; regime of protection; segment as unit of protection; capabilities; enter capability; asynchronous events>

NeeW74 Needham, R.M. & Walker, R.D.H. Protection and process management in the "CAP" computer. IWPOS74 155-160 [* Non-hierarchical protection in a hierarchically-structured system. *] <capability segment; indirection table; ENTER capability; protected procedure; hierarchical process structure>

Neu+76 Neumann, Peter G.; Feiertag, Richard J.; Levitt, Karl N. & Robinson, Lawrence Software development and proofs of multi-level security. Proc. 2nd Intern. Conf. on Software Engineering IEEE 1976 421-428

Neu+77 Neumann, Peter G.; Boyer, Robert S.; Feiertag, Richard J.; Levitt, Karl N. & Robinson, Lawrence A provably secure operating system. Stanford Research Institute Project 4332 Final Report 77.2.11 483p [* A five-stage design methodology for general-purpose operating systems, with assertions stated and proved in an assertion language common to all stages; and the design of a secure operating system achieved via that methodology, structured as a hierarchy of abstract machines. *] <alteration principle; detection principle; denial of service; leakage, information; capabilities; objects; access code; type manager; revocation, selective; lost-object problem; Trojan horse attacks; mediated access; mutually suspicious subjects; memoryless operation; military security classification; need to know; inference; confinement principle; *-property; security kernel; C-list; subjects; domains; rings; call and return mechanism; capability channels; revocable copy; distinguished entry>

Neum73 Neumann, Peter G. (reporter) Report of evening session on protection. SIGPLAN Notices 8,9(73.9) (PLOS73) p27 <hidden channels; move-without-reading; read-without-copying; user interface; principle of maximum security; protection as restriction>

Owen71a Owens, Richard C. Primary access control in large-scale time-shared decision systems. (M.S. Thesis) MIT Project MAC TR-89 71.07 91p

Owen71b Owens, R. Evaluation of access authorization characteristics of derived data sets. Proc. 1971 ACM-SIGFIDET Workshop on Data Description, Access and Control 263-278

Palm73 Palme, Jacob Protected program modules in Simula 67. Research Institute of National Defense, Stockholm, Sweden FOA P Report C 8372 73.7 26p NTIS: PB-224 776 [* Requirements for <inter-module protection>

in programming systems and languages; most of them satisfied by Simula 67.
A <HIDDEN specification> is proposed to prevent external access to class
attributes.*]   <classes, Simula 67>

Palm74 Palme, Jacob Software security. Datamation 20,1(74.1) 51-55
[* Brief tutorial. *]   <deduction problem; file keys; error patterns>

ParP74 Parnas, D.L. & Price, W.E. Using memory access control as the
only protection mechanism. IWPOS74 177-181 [* Argues that a virtual
memory that provides a separate address space for each process is the
only protection mechanism needed for basic access limitation. *]
<virtual memory as protection mechanism; need-to-know principle>

Pope73a Popek, Gerald J. Access control models. (Thesis) Harvard
Univ. Center for Research in Computing Technology 73.2 153p NTIS:
AD-761 807 [* Model based on a <restriction graph> whose nodes are
<security objects> and edges are <access paths>; an <access map> from
<actors> to nodes is implemented as a map from actors to boolean <key
variables> and a map from edges to boolean <lock functions> of these
variables; implementation algorithms. *]   <locks and keys; collusion;
filtering property; access graph; access control list>

Pope73b Popek, Gerald J. Correctness in access control. ACM73 236-241
[* <Set-theoretic model> of a <security system>, with proof of
correctness. *]   <inference problem; statistical access problem; kernel>

Pope74 Popek, Gerald J. Protection structures. Computer 7,6(74.6)
22-33 [* Brief but comprehensive survey. *]   <mutually suspicious
subsystems; memoryless process; statistical access; inference; errors,
examples; parameter checking; synchronization; higher level errors; hidden
channels; security object; passive object; active object; protection data;
update program; enforcement rule; access matrix; rights transfer
primitives; capabilities; environment binding; domain; sphere of
protection; c-list; revocation; locked boxes; access control list; rings;
seal/unseal; data-dependent access decisions; formularies; principle of
least privilege; grain of protection; security kernel; virtual machines;
locks and keys; scope of names; redundant checking; penetration>

PopK74a Popek, Gerald J. & Kline, Charles S. A verifiable protection
system. SIGPLAN Notices 10,6(75.6) (ICRS75) 294-304 [* <Security
kernels>, <virtual machines>, and program verification; design
considerations of the UCLA-VM System. *]   <security sensitive instructions;
security kernel, functions; input/output; data security, def.; security
objects; access predicates; updater; capability faulting; interruptibility;
privileged code, exclusion from user process; scheduling; file management
kernel; existence, knowledge of; kernels, levels; levels of mechanism;
direct access predicate; indirect access predicate; objecthood; Morse Code
problem; vulnerabilities, multilevel>

PopK74b Popek, Gerald J. & Kline, Charles S. Verifiable secure operating
system software. NCC74 145-151 [* Approach to providing verifiable
security; the applicability of <security kernel> designs, virtual machine

work, and program verification techniques; the UCLA-VM system. *]
<constraints; security objects; accessible sets; policy, def.; modularity;
owner; virtual machines; security primitives; Morse Code problem; updater>

Pric73 Price, William Robert Implications of a virtual memory mechanism
for implementing protection in a family of operating systems. (Thesis)
Carnegie-Mellon Univ. Computer Science Dept. 73.6 251p NTIS:
AD-766 292 [* Operating system design featuring local working subsets of
virtual address spaces as domains of protection; Parnas specifications of
the operating system modules; formal verifications. *]

Rede74 Redell, David D. Naming and protection in extendible operating
systems. (Thesis) MIT Project MAC TR-140 74.11 166p [* Features
and goals of typical capability systems, especially those related to
<revocation> and <type extendibility>, and a proposed implementation
for a system that handles both these problems using <sealed
capabilities>. *] <base level (kernel); domains and processes;
communication, interprocess/interdomain; lost object problem; capabilities,
protection of; identifiers, unique; caretaker domain; process control as
capability privilege; ownership privilege; capabilities, indirect, chains;
amplification, authorization; operators, non-monadic; capabilities, sealed;
capability systems, goals; subletting; revoker capability; revocability,
revocable; trust, changing levels; locker capability; extender capability;
parameters, revocable; directories in capability system;
comprehensibility of protection mechanisms; propagation, knowledge>

RedF74 Redell, D.D. & Fabry, R.S. Selective <revocation of capabilities>.
IWPOS74 197-209 [* Goals for revocation schemes; two domain-independent
schemes based on the notions of <indirection and control>; base-level
implementation. *] <revocability of revocability; copy of capability,
literal/revocable>

Rhod75 Rhode, R. Secure multilevel virtual computer systems. Mitre Corp.
MTR-2890 ESD-TR-74-370 75.2 33p NTIS: AD/A-007 059

Rob+75 Robinson, Lawrence; Levitt, Karl N.; Neumann, Peter G. & Saxena,
Ashok R. On attaining reliable software for a secure operating system.
SIGPLAN Notices 10,6(75.6) (ICRS75) 267-284 [* Design methodology for
and features of an operating system, with security and concurrent
verification as goals. *] <type manager; protection theorems; security
problems, special; security, def.; security kernel; capabilities; access
vector; capability manager>

Rote74 Rotenberg, Leo J. Making computers keep secrets. (Thesis) MIT
Project MAC TR-115 74.2 393p [* Mechanisms designed to solve classes
of problems associated with <proprietary services; privacy restrictions>;
and <authority hierarchies>. *] <segments; access control lists;
capabilities; capability lists; domains, postulates; protection, abstract
formulation; message system; caretaker program; encapsulation; argument
passing; name spaces; naming hierarchy; access control packet; revocation;
ownership of domains; call-out; call-in; capabilities, passing of; hidden
data; argument spying; blind service; benign domain; billing; accounting

channel; proprietary services, maintenance; locksmith; call packet;>

Rote76 Rotenberg, Leo J. (Letter) Operating Systems Review 10,2(76.4)
5-6 [* On the <soundness> of the privacy restriction mechanism described
in [Rote74]. *]

Saal77 Saal, Harry J. A hardware architecture for controlling information
flow. IBM Research RC 6414 (#27675) 77.2.28 30p [* Proposes an
enhanced <capability vector mechanism> that improves on traditional
capability schemes, which are shown to be inconsistent with the <least
privilege principle> and with <information flow requirements>.
(Abstract) *]

SalS75 Saltzer, J.H. & Schroeder, M.D. The protection of information in
computer systems. Proc. of the IEEE 63,9(75.9) 1278-1308 [* Tutorial
survey: basic principles; <list-oriented mechanisms> vs. <ticket-oriented
mechanisms>; <dynamic authorization>, <authority structures>, and
<protected subsystems>. *] <access control list; capabilities; design
principles; failsafe principle; separation of privilege; least privilege;
psychological acceptability; descriptor; principal; segment; domain;
revocation; propagation; review of access; access controller; protection
group; self control; hierarchical control; prescript; discretionary
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